

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

**ETM2046 – ANALOG AND DIGITAL COMMUNICATIONS
(RE)**

07 MARCH 2020
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 8 pages including cover page and appendices with 4 questions only.
2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the answer booklet provided

QUESTION 1

a) A function $x(t)$ is defined as the following

$$x(t) = \begin{cases} 0 & \text{for } -\pi \leq t < -\pi/2 \\ 2 & \text{for } -\pi/2 \leq t < \pi/2 \\ 0 & \text{for } \pi/2 \leq t < \pi \end{cases}$$

(i) Find the trigonometric Fourier series of $x(t)$ up till the 3rd harmonics ($n = 3$).

[10 marks]

(ii) Sketch the amplitude spectrum of $x(t)$ based on your answer in part (i).

[5 marks]

b) Given $x(t) = \text{rect}\left(\frac{t}{4}\right)$, find the Fourier Transform of:

i) $3x(t) + x(2t)$

ii) $x(t)\exp(j6\pi t)$

iii) $\frac{d^2 x(t)}{dt^2}$

[4+3+3 marks]

Continued

QUESTION 2

- (a) A carrier has an amplitude of 5V and its frequency is 1MHz. It is modulated by an 8kHz signal and the modulation index is 0.6.
- (i) Calculate the amplitude of the modulating signal. [2 mark]
 - (ii) Derive the time domain mathematical expression and sketch the single-sided frequency spectrum for the Double Sideband Large Carrier (DSB-LC) modulated signal. [5 marks]
 - (iii) Derive the time domain mathematical expression and sketch the single-sided frequency spectrum for the Double Sideband Suppressed Carrier (DSB-SC) modulated signal. [5 marks]
 - (iv) Write down the time domain mathematical expression and sketch the single-sided frequency spectrum for the Single Sideband (SSB) modulated signal, given the lower sideband is transmitted. [2 marks]
 - (v) Write down the time domain mathematical expression and sketch the single-sided frequency spectrum for the Single Sideband (SSB) modulated signal, given the upper sideband is transmitted. [2 marks]
- (b) An FM waveform is defined by $x(t) = 20\cos(\pi \times 10^7 t + 2\cos(\pi \times 500t))$. Determine
- (i) The modulation index, β . [1 mark]
 - (ii) The maximum frequency deviation, Δf . [2 marks]
 - (iii) The average power of the modulated signal. [2 marks]
 - (iv) The power in the largest sidebands. [2 marks]
 - (v) The bandwidth of the FM signal using Bessel function table. [2 marks]

Continued

QUESTION 3

(a) Given a PCM binary data 10101101. Sketch the corresponding signalling line code waveforms of the PCM binary data using:

- i) Unipolar NRZ
- ii) Polar NRZ
- iii) Unipolar RZ
- iv) Manchester NRZ

[8 marks]

(b) A linear PCM decoder is used to convert a sinusoidal signal to a PCM signal. The sinusoidal signal has an amplitude of 0.6V and a frequency of 8kHz. Given that the quantizer has 256 levels. Determine:

- (i) The minimum required sampling frequency, f_s

[2 marks]

- (ii) PCM bit-rate

[5 marks]

(c) A 9,600 bits/s data terminal is connected to a modem. What is the transmission bandwidth, B_T , required at the modem output for each of the following schemes? 50% roll-off shaping is used in all cases.

- (i) Binary ASK.

[3 marks]

- (ii) Binary FSK. Assuming that the frequency deviates $\pm 3,600$ Hz about the carrier.

[4 marks]

- (iii) 16-state QAM.

[3 marks]

Continued

QUESTION 4

- (a) A discrete memoryless source has an alphabet of five symbols whose probabilities of occurrence are as described below.

$$P(S_0)=0.45, \quad P(S_1)=0.22, \quad P(S_2)=0.14, \quad P(S_3)=0.10, \quad P(S_4)=0.09$$

- i) Construct the Huffman code for this source. [9 marks]
 - ii) Compute the average Huffman codeword length, L . [3 marks]
 - iii) Calculate the entropy of the source, H . [3 marks]
- (b) A computer keyboard can generate 110 different characters. Each character is sent in a codeword over an additive white Gaussian noise (AWGN) channel, which has a bandwidth of 3.2 kHz and signal-to-noise ratio (SNR) of 20dB
- i) Determine the number of bits required to code each character? [3 marks]
 - ii) How many characters can be transmitted in one second to achieve small error probability? [3 marks]
 - iii) If each character is equally likely to be sent, find the information content per character, H [4 marks]

Continued

Appendix I: Table of Bessel Function

$\beta \backslash n$	0.05	0.1	0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	7.0	8.0	10.0
0	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178	0.300	0.172	-0.246
1	0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2		0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3				0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4						0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5								0.007	0.043	0.261	0.348	0.186	-0.234
6								0.001	0.011	0.131	0.339	0.338	-0.014
7									0.003	0.053	0.234	0.321	0.217
8										0.018	0.128	0.223	0.318
9										0.006	0.059	0.126	0.292
10										0.001	0.024	0.061	0.208
11											0.008	0.026	0.123
12											0.003	0.010	0.063
13											0.001	0.003	0.029
14												0.001	0.012
15													0.005
16													0.002
17													0.001

Appendix II: Table of Trigonometric Identities

$$\sin A \sin B = \frac{1}{2} [\cos(A - B) - \cos(A + B)]$$

$$\cos A \cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$$

$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A + B) = \cos A \cos B - \sin A \sin B$$

$$\sin \theta = \frac{1}{2j} [e^{j\theta} - e^{-j\theta}]$$

$$\cos \theta = \frac{1}{2} [e^{j\theta} + e^{-j\theta}]$$

Continued...

Appendix III: Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi f t_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a t }$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$\text{rect}\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}\text{rect}\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$

Continued...

Appendix IV: Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{ a } X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n} x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n} X(f)$
Time Integration	$\int_{-\infty}^t x(\tilde{t}) d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f} + \frac{1}{2} X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^f X(\tilde{f}) d\tilde{f}$

End of Paper